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TELUS
(Telemetric Universal Sensor)

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May 1965

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Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas

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FOREWORD

This report was prepared in the Microbiology Section of the Biosciences Branch under Task No. 775402. The paper was submitted for publication on 18 December 1964. The work was accomplished between July 1963 and December 1964.

The coder and searcher used in this study were purchased with funds from the Laboratory Director's Fund of the USAF School of Aerospace Medicine.

This technical documentary report has been reviewed and is approved.

Harold V. Ellingson
HAROLD V. ELLINGSON
Colonel, USAF, MC
Commander

ABSTRACT

There was need for a flexible complex of receiving and evaluating instruments for sensing physiologic and biologic analyses performed remotely by various field transducers. This need has been met by the design and development of TELUS (Telemetric Universal Sensor), a one-man laboratory console capable of receiving, quantitating, comparing, coding, storing, searching, retrieving, and distributing electrical and electromagnetic data. These data are received and distributed by radio and telephone. Field tests of TELUS indicate good performance characteristics for evaluating four channels of telemetered data and providing two-way communication between the laboratory and remote testing areas.

TELUS

(Telemetric Universal Sensor)

I. INTRODUCTION

When the feasibility of short- and long-range telemetry from certain analytic field sensors for biologic fluids was established (1-6), it became evident that an integrated functional console to be operated in the laboratory was required. The console was to receive, quantitate, compare, code, store, search, retrieve, and distribute data from field sensors located at some remote site. These functional needs generated the design and development of the TELUS (Telemetric Universal Sensor). TELUS provides the capability for monitoring any electrical or electromagnetic output from field-sensing instruments and quantitating these data into readout instruments (oscilloscope, strip-chart recorder), while simultaneously distributing the data signals to other laboratories.

II. SUMMARY

Successful integration of modified, commercially obtainable components has resulted in the functional design and development of a laboratory console that is suitable for sensing several physiologic and biologic transducers located remotely. Field tests of TELUS have resulted in a telephone-radio, two-way communication system that can be operated by one man in a laboratory. The four-channel input of TELUS can be in electrical or electromagnetic form and the output distributed, taped, and viewed simultaneously on a dual-channel oscilloscope and a strip-chart recorder. Comparison of data is anticipated by use of two instrumentation tape recorders simultaneously and two-way radio telemetry from field sensors located remotely.

III. DESIGN AND DEVELOPMENT

TELUS was designed by the authors and developed entirely at the School of Aerospace Medicine from commercial components. Some of the instruments incorporated into the console were modified electronically to meet the required performance integration. The wooden console is 2 meters high, 1.5 meters wide, and 0.9 meter deep, with instruments grouped into three vertical functional modules, each of which is in a double oblique plane for easy one-man operation. Access to the back of the instruments is through three separate panel openings in the rear of the console. Two instrumentation tape recorder-reproducers flank the console in matching two-tone wooden cabinets.

IV. FUNCTIONAL CAPABILITIES

TELUS is designed to:

a. Receive telemetered signals directly or indirectly from air or ground by radio, telephone, and magnetic tape.

b. Initiate or relay data to space or ground stations.

c. Decode frequency-modulated signals.

d. Place a binary code (000-999) on both incoming and outgoing data and utilize this code through an automatic searching system to retrieve information from magnetic tape.

e. Present channels of data for viewing on a dual-channel oscilloscope and a two-channel strip-chart recorder.

f. Simultaneously receive four channels of the same or different information (either frequency-modulated or direct—i. e., voice). This information can be simultaneously recorded on any of fourteen channels on magnetic tape.

V. APPLICATIONS

TELUS can be linked directly or indirectly to sensors for quantitation of:

a. Physiologic data (e.g., electrocardiography, electroencephalography, respirometry, sphygmomanometry).

b. Physical data (e.g., gas, pressure, strain, temperature).

c. Physical-chemical data (e.g., pH, turbidimetry, spectrophotometry, reflectometry, nephelometry, Liesegang phenomenon).

VI. GENERAL OPERATION

High-frequency electromagnetic waves picked up by the antenna are conducted to the receiver (*B* of fig. 1). Audio signals can be received via the telephone circuit (*T*). Whenever necessary, the output of the receiver (or telephone) may be increased by connecting the receiver (or telephone) to one of the amplifiers (*C*) before the information is relayed to the next circuit. The signals are decoded by discriminators (*A*), according to the frequencies being used, and transposed into individual characteristics with analog or digital outputs, which can be visualized on a dual-channel oscilloscope (*I*) and a two-channel, galvanometric strip-chart recorder (*S*). Simultaneously, the signals can be stored on one to fourteen channels of magnetic tape (*X*), paralleled with a preselected binary code (*M*) and audio recording from headsets (J, J_1). A high-frequency counter (*R*) can be used to visually indicate the frequency of the incoming or outgoing audio information before distribution. When the binary code used to identify data is fed onto magnetic tape, such code can be electronically sensed on playback by the tape searcher (*L*), which automatically stops the recorder when the desired identifying number appears in the reading head of the recorder (*X*). Controls (*E-H*) provide remote operation of one tape recorder from the right side of TELUS.

TELUS is capable of receiving frequencies of 50 to 260 mc. These signals can have bandwidths of 0 to 300 kc. Received signals can be of the video, audio, or subcarrier type (400 cps to 80 kc./sec.). Radio-frequency carriers can be amplitude- or frequency-modulated.

Distribution of data through and within TELUS is accomplished by interconnecting components in various sequences (modes). Central programing and distribution were selected to maximize the utilization of available instruments. These essential instruments are assembled in the console with outputs and inputs connected to a central grid system. This central grid-distribution system is adjusted for 1.4-volt distribution into 1,000-ohm loads to allow multiple bridging for chart, oscilloscope, recorder, and amplifier circuits, while minimizing cross-talk and loading problems. TELUS is provided with forty vertical grids and thirty horizontal grids (*O* of fig. 1). The input or output of each instrument is assigned a position at one of the forty vertical grids. The thirty horizontal grids are called switching channels. Any of the vertical instrument connections of TELUS can be connected to any of the horizontal switching channels by placing a peg in the grid where the circuits cross. The horizontal switching circuits are brought out to the rear terminals of TELUS. Antenna, telephone lines, and tape recorders are connected to these rear terminals. For each specific experiment there is a corresponding arrangement of pegs in the grid-distribution block. A plastic overlay is made with holes where the pegs are to be inserted. To preset TELUS for a given mode of operation, the proper overlay is selected and pegs inserted. This gives TELUS the flexibility of a universal system with the reliability of an integrated system.

TELUS is organized around a system of FM/FM telemetry. An advantage of this system is that data can be provided for a new

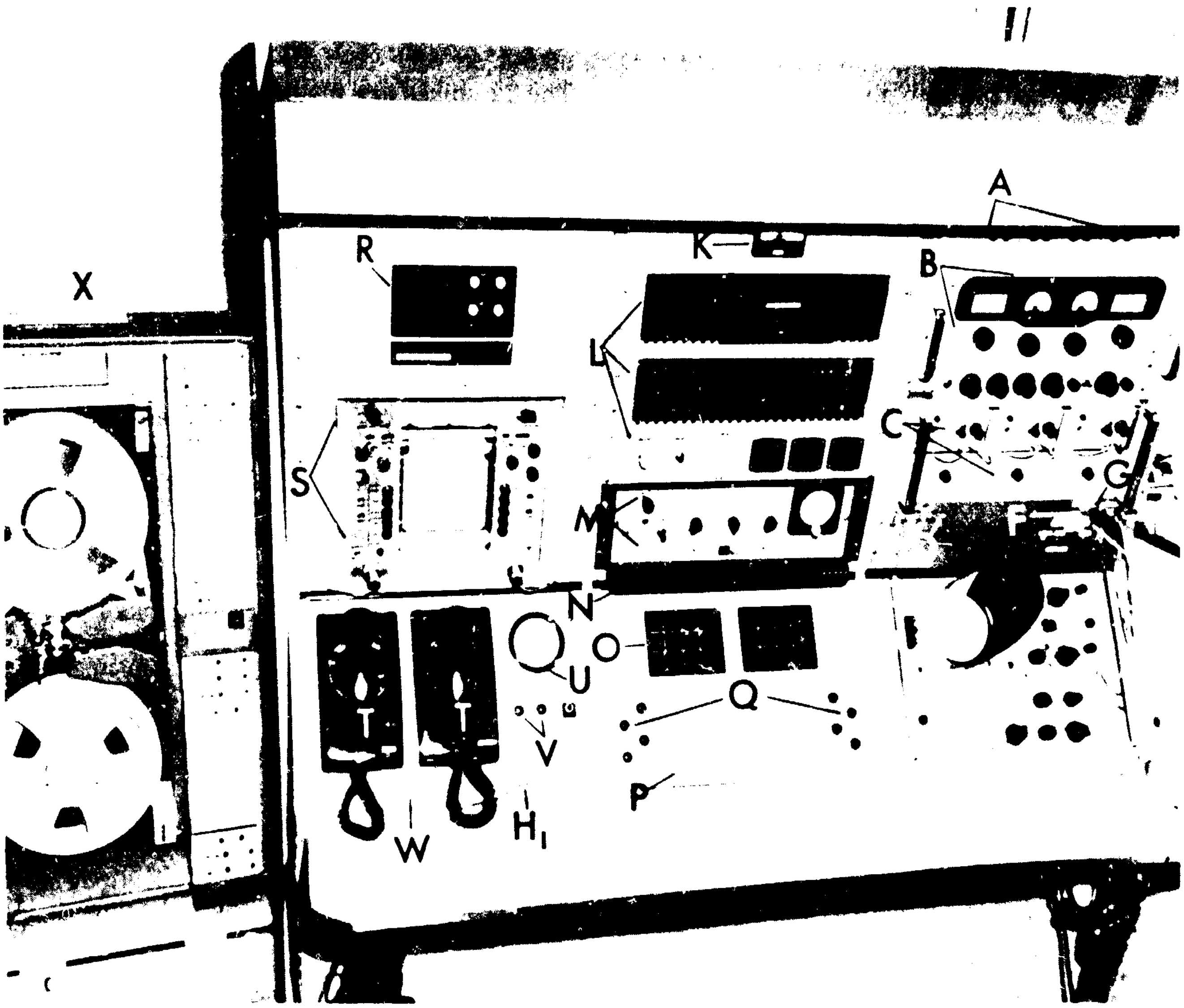

FIGURE 1

TELUS (Telemetric Universal Sensor).

A. Discriminator (decoding) rack

B. Receiver (50 to 260 mc.)

C. Operational amplifiers

D. Filters

E. Tape recorder (remote control)

F. Headset amplifier

G. Delayed playback control

H — H_1. Headset interconnect

I. Oscilloscope (dual-channel)

J — J_1. Headset

K. Monitor meter

L. Magnetic tape searcher (digital)

M. Magnetic tape coder (digital)

N. Switch-pin rack

O. Program boards (switch-pin type)

P. Test panel (terminal pin jacks under the cover)

Q. Test panel selector switches

R. Audio frequency counter

S. Strip-chart recorder (dual-channel)

T. Telephone (send, receive)

U. Internal timer

V. Telephone selector switches

W. Telephone key switch

X. Magnetic tape recorder (two separate recorders, fourteen channels each, connected into TELUS) measurement by the simple addition of another subcarrier, Data come from instruments widely separated; thus, the subcarrier system is the best method of combining data.

TELUS includes a transmitter that can relay any signal via other communication links over 245.8 mc. FM (approx. 10 watts).

VII. GRAPHIC INTERPRETATION

When the feasibility of transmitting data from a prototype Bio-telescanner via the Military Affiliated Radio Service from one hemisphere to another was demonstrated in 1962 (3, 6), emphasis was placed on refinement and integration of the Bio-courier (2)–TELUS combination.

One type of biologic analyses, precipitin (antigen-antibody) systems in agar gels, is shown in figure 2. Columns of this type are photoelectrically scanned by the Bio-telescanner (5) shown in figure 3. Changes in the photoelectric cell output are fed to the Bio-transceiver (fig. 4), where the transmitter is located. The transceiver was designed as a companion instrument to provide sustained battery power for the telescanner and a two-way telemetry link between an operator in the field and the scientist in the laboratory. (For space vehicles, a transceiver would not be required since the 28-volt input to the scanner and the telemetry would be supplied by the vehicle.)

Quantitation of precipitin reactions and other essential data sent from the Bio-telescanner in the field to TELUS takes the graphic form shown in figure 5. In this instance, data from two subcarriers (1.7 kc. and 1.3 kc.) are shown. The upper half of figure 5 (1.7 kc.) shows a series of three square waves on the left. The amplitude of these indicates the temperature in the telescanner and the first and second digits of the reaction being scanned. Should atmospheric disturbances (static) affect transmission of the data, these would be shown as erratic spikes in the horizontal components of the square waves. An indicator of this nature is essential for determining the quality of the transmission. The sequence of spikes further to the right on the upper half of figure 5 represents the binary (yes-no) code placed on each scan by the TELUS operator. The 12 spikes are divided into three groups of 4. Within each group the spikes are given the value of 1-2-4-8, reading from right to left. Where spikes are toward the top (position yes—e.g., 2, 1), the values for each group are added to give the total for that group. By combinations of yes and no within each group, a three-digit numeric code from 000 to 999 can be registered. Binary codes are placed on the 1.7-kc. signals by the TELUS operator, thus, energizing the magnetic tape coder (*M* of fig. 1) to be used later by the magnetic tape searcher (*L* of fig. 1) for automatic searching and retrieval.

The lower half of figure 5 is the 1.3-kc. subcarrier tracing the graphic picture of a reaction column. An explanation of the graph is given in the figure legend.

VIII. FIELD TESTS

The console described in this report is used routinely to monitor precipitin analyses via telemetry from an automatically programed Bio-telescanner (5). In addition, during the past year, TELUS has been used several times in a two-way communication system to monitor physiologic changes of subjects in altitude chambers. In these instances, communication from TELUS was by telephone and data from the chambers sent via radio to the laboratory. Other field tests, as exercises, have been done in two-way communication by a combination of radio and telephone linking the Bio-telescanner and its operator, located in an altitude chamber, with TELUS located in another building about 200 yards away.

Successful operation of the Bio-courier–TELUS telemetry system will depend on established communication links. Anticipated paths and field areas to be utilized are shown in figure 6. Each of the remote locations has numerous microbiologic problems that can be solved better and more efficiently through cooperative research via telemetry. It is this approach for which TELUS was designed.

FIGURE 2

Precipitin (antigen-antibody) reactions in agar diffusion columns. The glass tubes are 60 mm. long and 4 mm., outside diameter. In most instances, photometric quantitation of the white zones at an early time when they are aggregated close to the interface gives the essential information.

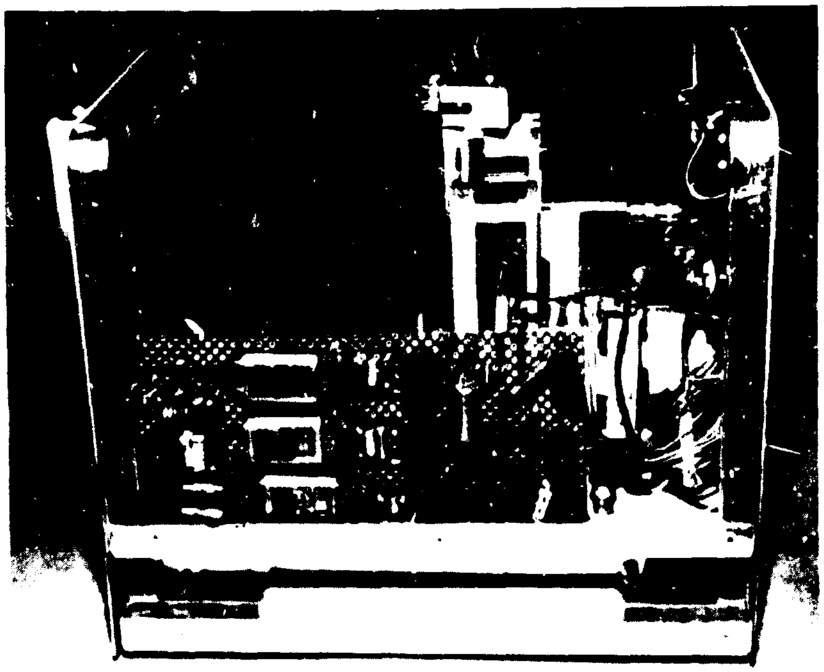

FIGURE 3

Bio-telescanner, model X-63B. Reaction columns are positioned in the round, black magazine. The black tube to the right moves the scanning beam in a vertical direction. In the later model, X-63C, the electronic deck in the foreground is positioned in a false bottom under the scanner.

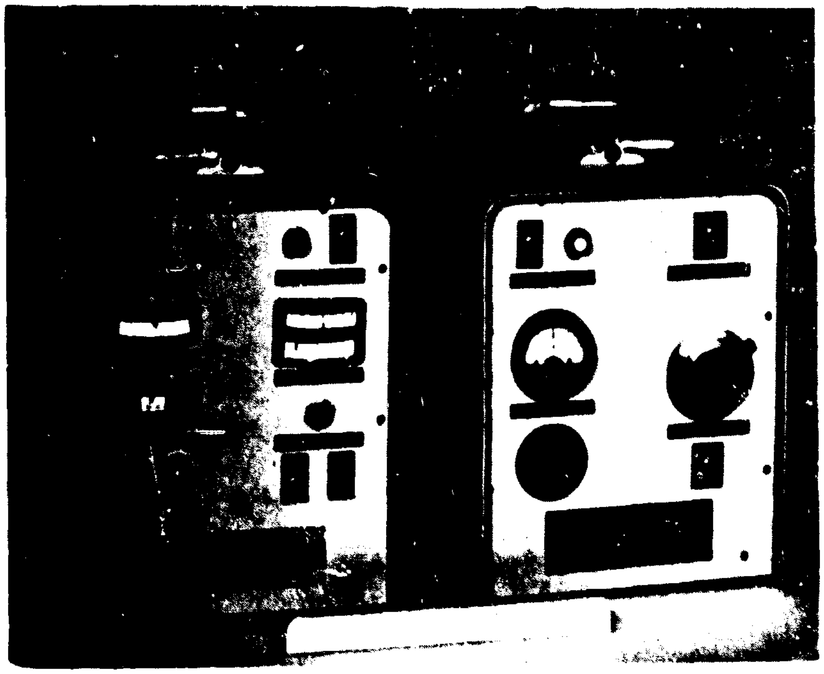

FIGURE 4

Bio-telescanner, model X-63C (left) and Bio-transceiver model X-63BR. The transceiver provides sustained battery power to the scanner and permits two-way communication between the operator in the field and the scientist at TELUS in the laboratory.

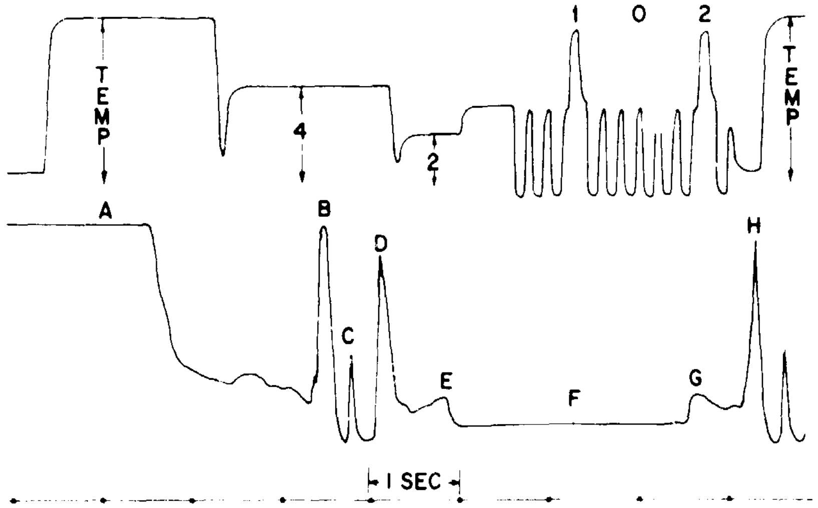

FIGURE 5

Graphic form of the telemetry data received by TELUS from the Bio-telescanner. The upper half of the figure (1.7 kc.) shows the temperature, magazine position, and an identifying binary code as explained in the text. The lower half (1.3 kc.) represents the following information concerning the reaction columns being scanned: A, *magazine changing position;* B, *deflection where the antigen (see fig. 2) meets the air;* C, *reference mark on the column;* D *and* H, *interface where antigen meets antiserum-agar;* E *and* G, *precipitin zone;* F, *antiserum-agar without reactions.*

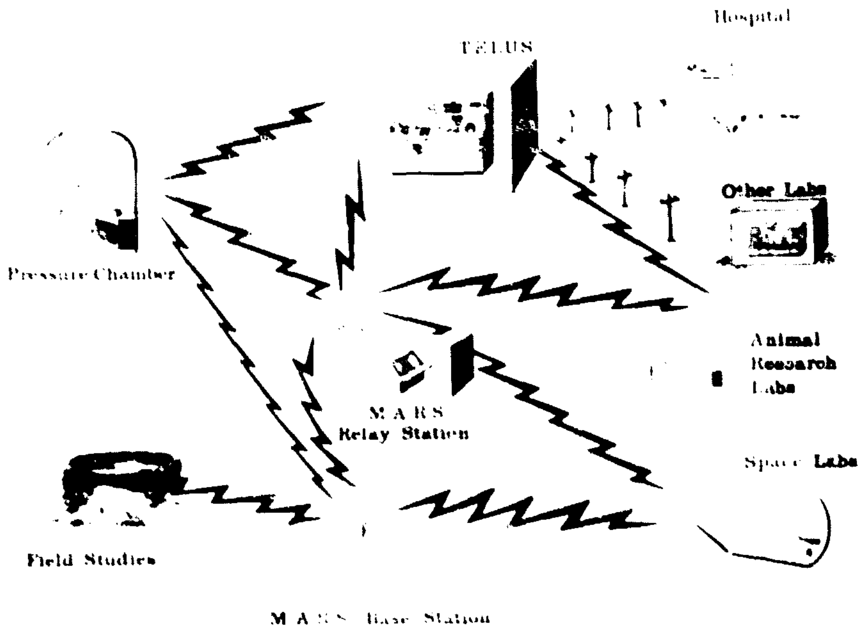

FIGURE 6

Anticipated sites for field studies and the communication links in the Bio-courier–TELUS system of telemetry of biologic reactions.

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